VEHICLE ARRESTOR SYSTEMS

FIELD OF THE INVENTION

This invention relates to equipment for arresting vehicles, particularly those interacting with the vehicle's tires.

BACKGROUND OF THE INVENTION

There are a number of reasons for which it is desirable to arrest a vehicle without the use of lethal force typically in police and military scenarios.

To this end a variety of systems have been developed including the type of system designed to target the tires of the vehicle to be arrested. The most common of these is the type designed to deflate the vehicles tires.

However, a drawback to this system is that the vehicle may continue on albeit at a slower rate. Also puncturing one or more tires at full speed of the vehicle may cause dangerous loss of control and stability potentially resulting in damage to the surroundings and/or harm to the driver/passengers.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a device for arresting the progress of a vehicle having wheels with rubber tires, the device being deployable on a road surface and comprising:

(a) at least one tire attaching member, (b) at least one elongated flexible member disposed along the direction of progress and adapted to wrap around the tires, the tire attaching member being fixed to the proximal end of the flexible member with respect to the vehicle's motion, and c) an arresting means attached to the flexible member and adapted to interfere with the vehicle motion. Thereby,

upon passage of the vehicle over the device, the tire attaching member attaches the flexible member to the vehicle tires so that the flexible member wraps around the tire, and the arresting means interferes with the motion of the vehicle so as to arrest it.

The tire attaching member may be a barb or spike adapted to pierce the tire and to resist being pulled out.

The elongated flexible member is a generally flat strip of durable material or a cable or chain, or may be a combination of both.

The device is preferably foldable and portable.

The device may have a plurality of elongated flexible members, wherein the arresting means is a rod disposed transversely to the flexible members and attached to the distal end of each flexible member with respect to the vehicle's motion. Preferably, the rod is deformable and capable of absorbing mechanical energy, for example a hollow metallic pipe.

In one embodiment, the rod is composed of a plurality of tubular elements, each one adapted for fixing to one of the flexible members. A cable passes through each tubular element, and has two end fittings fixed thereto, so as to hold the tubular elements together. Preferably, at least one of the end fittings is fixed releasably to the cable so as to enable replacement of the tubular elements and the elongated elements, and\or adjustment of the device width.

In another embodiment, the tire attaching members may be anchoring spikes attached to cables or chains and adapted to pierce the tire and to resist being pulled out so that strong pulling force would tear and/or strip the tire at least partially off its wheel rim. The anchoring spike may have at least one movable folded part adapted to unfold inside the tire after piercing it. The movable part is preferably spring-loaded and held in folded position by a catch releasable by interaction with the pierced tire.

The arresting means may be a rigid member disposed transversely to the cables or chains and attached to the distal end of each cable or chain with respect to the vehicle's motion. The rigid member may be a rigid rod or beam.

Preferably, the rigid member is a flat housing accommodating the cables or chains and the anchoring spikes, and having a sloping surface at its proximal and distal ends facilitating passing of the vehicle tires.

The device preferably comprises a movable cover allowing hiding said anchoring spikes so as to let a vehicle pass over said device without being arrested.

In yet another embodiment of the device, the attaching member may be a layer of sticky material applied to the upper surface of an elongated strip. The arresting means may be a slippery layer at the bottom surface of the strip, for example a smooth and flexible steel net.

According to a second aspect of the present invention, there is provided a device for arresting the progress of a vehicle having wheels with rubber tires, the device being deployable on a road surface and comprising a) a plurality of freely rotating cylinder or ball-shaped members; b) supporting means adapted to hold the freely rotating members with axes of rotation substantially perpendicular to the vehicle motion and at predetermined distance from one another. The freely-rotating members are adapted to engage at least one of the vehicle tires and prevent its contact with the road surface, thereby arresting the vehicle.

In one embodiment of the device, the plurality of freely rotating members comprises a series of adjacent rotary members of substantially equal diameter and a member of larger diameter disposed distally of the series.

The device preferably comprises a friction plate disposed distally of the series of rotating members and carrying the member of larger diameter, the plate being adapted to absorb at least part of the momentum of the arrested vehicle and/or to dissipate the associated mechanical energy by friction with the road surface.

The device may further comprise two freely rotating members of medium diameter, one disposed proximal of the series and the other disposed between the series and the member of larger diameter.

The larger diameter may be about 25-40% of the vehicle tire diameter, the medium diameter may be about 10-15% of the vehicle tire diameter and the diameter of the members in the series may be about 5% of the vehicle tire diameter.

In another embodiment of the device, the plurality of freely rotating members are of substantially equal diameter and the supporting means is a low bridge-like construction with ascending-descending slopes at the distal and proximal ends thereof adapted to accommodate the vehicle with all its tires contacting only the rotating members.

The device comprises a plurality of supports disposed between the freely rotating members and adapted for lifting and lowering so that, when lifted, the supports may carry the vehicle tires and allow the vehicle to travel along and leave the arresting device. The supports may be mounted on one or more substantially horizontal plates disposed under the rotating members.

The device comprises one or more jacks adapted for lifting the supports, for example powered mechanical jacks, hydraulic or pneumatic jacks.

The device may comprise a means for towing the vehicle to or from said bridge-like construction such as a winch.

The device is suitable for use in a remotely controlled roadblock arrangement comprising signposts, road humps, deployable road spikes, traffic lights, video cameras, voice communication means, lighting and personal identification means, etc. Preferably, at least one of the video cameras is disposed in the device so as to transmit picture of the vehicle underside.

According to a next aspect of the present invention, there is presented a device for arresting the progress of a vehicle having wheels with rubber tires, the device being deployable on a road surface and comprising a) at least one tire piercing member disposed so as to meet said tire under angle suitable for piercing, and (b) means adapted to tear and strip the tires off their wheel rim after the piercing. The device may comprise mounting means for attaching the piercing members thereto under said suitable angle.

In one embodiment, the device comprises a plurality of tire piercing members disposed in a rigid flat housing. The housing is open from above and accessible by the vehicle tires at least from the proximal end thereof.

The housing may comprise two or more parts each containing a portion of the tire piercing members, the housing parts being stackable so as to hide the tire piercing members. The parts of the housing may be pivotally connected. The device may further comprise a movable cover allowing hiding the tire piercing members so as to let a vehicle pass over the device without being arrested. Preferably, the housing is adapted for moving and transporting.

The piercing members may be anchoring spikes or blades, for example having a movable folded barb adapted to unfold inside the tire after piercing it. Preferably, the movable barb is spring-loaded and held in folded position by a catch releasable by interaction with the pierced tire.

The piercing members may be attached to the housing by flexible cables or chains allowing wrapping around the tires after the piercing.

In another embodiment, the device comprises one tire piercing member having a means for releasing pressurized gases into the tire after piercing it so that the tire is at least partially blown off its wheel rim. The piercing member preferably has a hollow piercing spike and a hollow cartridge in fluid communication with the spike. The cartridge contains volatile, reactive or explosive material capable of producing pressurized gases upon activation.

The cartridge may be adapted for activation of the material by pressure applied to the cartridge by the vehicle tire, or alternatively, the device may comprise means for remote activation of the material by an operator.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

Fig. 1A is a schematic top view of a vehicle arresting device in the form of "stick in the wheels" according to one aspect of the invention;

Fig. 1B is a schematic side view of the device in Fig. 1A;

Figs. 2A and **2B** are schematic sectional views of strips used in the device of Fig. 1;

Fig. 3 is a perspective view of another embodiment of the "stick in the wheels" arresting device;

Fig. 4 is a schematic side view of a vehicle arresting device in the form of "spinning cylinders" according to another aspect of the invention;

Fig. 5A is a schematic side view of another embodiment of the "spinning cylinders" arresting device;

Fig. 5B is a sectional view of the vehicle arresting device in Fig. 5A;

Fig. 6 is a schematic perspective view of a remotely operated roadblock using the vehicle arresting device of Figs. 5A and 5B;

Figs. 7A-7C are front schematic views of a vehicle arresting device according to yet another aspect of the invention in which the vehicle tire is at least partially removed from the associated wheel rim;

Fig. 8 is a schematic perspective view of a housing for the vehicle arresting device of Figs. 7A-7C;

Fig. 9 is a schematic perspective view of a variation of the vehicle arresting device shown in Figs. 7A-7C with tire anchoring members attached to cables;

Fig. 10 is a sectional view of a tire anchoring member used in the vehicle arresting device of Fig. 9, anchored to the vehicle tire;

Fig. 11 is a cross-sectional view of a tire attaching device with pyrotechnic charge according to another aspect of the present invention.

Figs. 12A and **12B** are schematic views of a vehicle arresting device in the form of "low friction stickers";

Fig. 12C is an enlargement of an area, marked II in Fig. 12B; and

Fig. 12D is an illustration of the vehicle arresting device of Figs. 12A and 12B shown engaging a vehicle tire.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Figs. 1A and **1B** there is shown a device **10** according to the present invention, for arresting a land-vehicle having rubber tires (hereinafter, "the vehicle", not necessarily shown). The device interferes with the operation of the wheels of the vehicle to be arrested and is therefore dubbed "stick in the wheels". Fig. **1A** shows a top view of the device and Fig. **1B** shows a side view thereof.

The device **10** comprises one or more members, for example, a mat or series of side-by-side strips/mats **11**, typically rectangular, each having a number of cables **12** running the length thereof. The cables have attached thereto a plurality of tire attaching members such as spikes **14**. At an end of the strips **11**, the end typically arranged to be the farthest from the oncoming tires, the cables **12** are attached to a wheel-rotation interfering member, represented by a rod **16**, running perpendicular to the cables. The rod **16** may be hollow, as illustrated in Figs. **1A** and **1B** which lowers its weight and results in easier handling thereof.

Figs. **2A** and **2B** illustrate a couple of exemplary arrangements for incorporating the cables **12** into the strips **11** or attaching them thereto. In Fig. **2A**, the cables **12** are molded into a rubber strip **17**; and in Fig. **2B** the cables are attached to the strip by one or more fabric layers **18**. The layers **18** may as well constitute the strip **11**.

When the vehicle tires roll onto the strip(s) **11**, the spikes **14** stick into the rubber tire causing the strip(s) to wrap around the tires. It is understood that the strip(s) **11** and cables **12** are appropriately flexible for this purpose. The arrangement is such that the strips **11** are well wrapped around the tires by the time the rod **16** is drawn up into the associated wheel well of the vehicle at which point the rod interferes with the body of the vehicle inhibiting rotation of the wheel(s) and causing the vehicle to stop.

Fig. **3** shows another embodiment **20** of the device in Figs. **1A** and **1B**. The rod **16** here is constituted of a plurality of short tubes **22** held together by a strong steel cable **24** passed through the tubes and equipped with end fittings **26** tightly secured to the cable **24**. The end fittings **26** are preferably mounted to the cable by releasable means such as quick release pin . Each of the straps **11** end in an eyelet (loop) **28** fitted over one of the tubes **22**. The straps **11** may be made of strong material which does not need reinforcing cables inside.

This embodiment allows modular assembly of different number of straps and tubes to enable adjusting the device for different road widths and to facilitate replacement of worn-out elements. The tubes **22**, preferably metal tubes, are deformable and capable of absorbing the mechanical energy (inertia) of the arrested vehicle whereby the arresting is less dangerous for the vehicle and the passengers.

Fig. 4 illustrates a device **30** for arresting a land-vehicle having rubber tires **31**, according to another aspect of the present invention. The device comprises a series of rotational members upon which the vehicle tires **31** may spin and is therefore dubbed "spinning cylinders" device. According to one embodiment, it is constituted by rods or cylinders including a holding cylinder or large cylinder **32** at one end of the series, a pair of medium sized cylinders **33** and **34** - one adjacent the large cylinder **32** and one at an opposite end of the series from the large cylinder, respectively. Between the two medium cylinders **33, 34** there are a plurality of smaller cylinders **36**. The cylinders **32, 33, 34** and **36** are attached one to the next at corresponding axes **32', 33', 34'** and **36'** thereof such that the cylinders may spin about their axes. The diameters of said cylinders may be about 25-40%, 10-15% and 5% of the vehicle tire diameter, respectively.

The cylinders **32, 33, 34** and **36** rest on the road surface **37** and are generally held in place by a friction plate **38** which is attached to the large cylinder **32** via a member such as a triangular block **39** - the friction plate and triangular block optionally being an integral member. The cylinders can be

actualized by a number of geometries, for example, one long rod, several rods, spherical members and the like.

When the vehicle's tires **31** – again, typically the front tires – pass onto the device, the vehicle is slowed by hitting the cylinders **32, 33, 34** and **36**, especially the large cylinder **32**, the entire device will then tend to slide in the direction in which the vehicle travels due to the vehicle's momentum (inertia), then the vehicle is arrested as its wheels interactively spin with the cylinders. This action is similar to the concept of a stationary exercise bicycle where the bicycle's wheel spins on a small wheel or cylinder attached to a frame.

With reference to Figs. **5A** and **5B**, there is shown another embodiment of an arresting device with "spinning cylinders". A free-roller barrier **40** comprises two elongated bridges **42**. Each bridge is a channel-like structure with side walls **44** supporting for free rotation a plurality of horizontal rollers **45** perpendicular to the channel axis, and ascending-descending slopes **46** at the ends of the channel. The bridges **42** are of suitable size and location to accommodate vehicles of various sizes with all their tires **31** supported by the free rollers **45**.

Between the rollers **45**, there is a plurality of rigid non-rotary supports **47** mounted on strong carrying plates **48** which can be lifted by jacks **49** above the rollers **45**. The jacks may be of any suitable type such as hydraulic, electromechanical or pneumatic, for example inflatable airbags under the plates **48**. The barrier **40** is installed permanently or in mobile fashion on the road.

In operation, a vehicle is allowed to approach the barrier **40** and climb onto the bridges **42** via the slopes **46** at low gear (low speed), with the rigid supports **47** raised. This is conventionally shown in the left half of the bridge **42** in Fig. **5A**. When all tires of the vehicle are on the bridges between the rollers **45**, the plates **48** with the supports **47** are lowered until the tires rest on the rollers **45**, as shown in the right half of the bridge **42**. It will be appreciated that with the tires **31** on the freely rotating rollers **45**, the vehicle cannot move forwards or backwards. If the vehicle should be allowed to travel, the jacks **49** are operated to raise the supports **47** above the rollers **45**. For the case of jack failure, a winch or

similar means may be installed nearby, to enable pulling the vehicle off the bridges **42**.

With reference to Fig. **6**, a remote control system for identification and control allowing closing down and opening of a roadblock **50** is shown built around a free-roller barrier **40**. The system comprises other devices and installations such as signposts **51**, road humps **52**, road spikes **53**, traffic lights **54**, cameras **55** and **56**, voice communication means **57**, lighting **58**, identification means **59**, etc.

The system is installed permanently or in mobile fashion, and is adapted to guide the vehicle towards the roadblock **50** at low travel speed. A system for driver identification uses ID-card reader **59** or picture/fingerprints/image transferring to the roadblock operator (not shown). Another system transfers an image of the vehicle's underside using, for example, video cameras **56** installed between the bridges **42**.

Figs. **7A-7C** are schematic front views of a vehicle arresting device **60** according to yet another aspect of the invention in which the vehicle tire **31** is at least partially removed from the associated wheel during arresting thereof.

In Fig **7A**, the device, shown in its closed position, comprises a base **61** and a corresponding top **62** each having rows of blades or spikes **64** protruding therefrom. The blades **64** may be integral or conveniently attached to the base **61** and top **62**, for example by being screwed thereto which would facilitate easy replacement should the need arise. It is noticed that the blades **64** are dimensioned not to interfere with each other when the device is in a folded position as seen in Fig. **7A**. Alternatively, the blades **64** may be positioned in an offset manner to avoid interference.

Fig **7B** illustrates the device **60** in a partially opened position; the opening aided by a pivot mechanism **66**. In Fig **7C**, the device **60** is seen in its fully open position, with both the base **61** and top **62** resting on the road surface **37**.

Prior to the approach of a vehicle to be arrested, the device **60** is deployed on the road surface **37**. When the vehicle tires **31** roll on the device, the blades

64 pierce the tires and grab on thereto such that while the vehicle advances, the tires are at least partially removed/peeled from the associated wheel rims and the vehicle is arrested. An example of a blade of tire engaging member facilitating this action is detailed below in reference to Fig. **10**.

If the device **60** is deployed and one wishes to allow vehicles to pass without arresting them, a covering may be placed thereon. An example of such covering in the form of a housing **70** is shown in Fig. **8**. The housing **70** comprises inclined slopes **72** and top surfaces **74** for allowing vehicles to conveniently pass thereover. When a vehicle to be arrested approaches the device **60**, the surfaces **72** and **74** may be removed, facilitated by handles **76**, thereby exposing the blades **64**.

Fig. **9** is a schematic perspective view of another embodiment **80** of the aspect of the invention illustrated in Figs. **7A-7C** and **8** including another variation of tire engaging member or blade. Here, the device **80** is shown exposed in a housing **81** similar to the housing **70**, and comprises tire anchoring members **82** having tire piercing members **83** at their upper ends. Each anchoring member **82** is attached by its bottom end to a cable **84** which in turn is attached to a hook **86**. The hooks **86** are engaged with a rod **88** running perpendicular to the cables **84**.

The blades **83** are seen in a closed position in Fig. **9**, and for example, may have a sharp conical profile for facilitating piercing of the tires **31**. Upon piercing of the rubber vehicle tire **31**, the blade **83** opens, as seen in Fig. **10**, to provide for anchoring at the tire.

The blades **83** may be opened by a variety of mechanisms. For example, they may be spring-biased toward the open position, however held closed by a catch (not shown). The catch may be released by the action of the tire **31** coming down around the catch at its pierce point.

The blades **83** are angled toward the vehicle tire **31** at an appropriate angle and may be fixed at this angle by any of a number of known means (e.g. by constructing the bottom ends of the tire anchoring members **82** to be so angled).

When a vehicle passes over the device, the blade **83** pierces the tire **31** and gets anchored therein. With the advance of the vehicle, the cable **84** gets drawn around the tire **31** and eventually the rod **88** in the hook **86** catches on the vehicle causing the anchored blade **83** to at least partially remove the tire **31** thereby arresting the vehicle. The cables **84** may be as well fixed to the housing **81**.

It will be appreciated that, before tearing the tire, the arresting device **80** operates essentially as the "stick in the wheel" device **10** (Fig. 1A) where the rod **88** or the housing **81** interfere with the vehicle wheels to reduce substantially the vehicle speed.

Fig. **11** shows a cross-section of a tire-attaching device **90** designed to remove at least part of the vehicle tire **31** from its wheel rim. This device **90** can be designed to be remotely deployed, for example by a remote control (not shown), or manually/mechanically deployed.

The tire attaching device **90** includes a hollow cartridge **92** comprising a hollow spike **94** at its top designed to penetrate the vehicle tire **31**. The cartridge **92** fits into a cartridge housing **96** comprising an upper housing **98** and a lower housing **100**, which have corresponding screw threads **102** and **104**, respectively, to allow them to be screwed to each other. The lower housing **100** is typically attached to a base **106** which could be a part of a road surface engaging structure (not shown in Fig. **8**) such as a known structure already in use. The tire attaching device **90** may be angled to ensure the best tire penetration as a result of its attachment to the base **106** or by other means, such as the geometry of the lower housing **100**.

The cartridge **92** also comprises a volatile/explosive or pyrotechnic material **108** at the bottom portion of the cartridge which, for example, can be activated in a manner analogous to that of a vehicle air-bag during a collision. For this purpose, the device includes a firing pin **110** adjacent the pyrotechnic material **108**. For the sake of safety, the device preferably comprises a safety catch **112** to prevent unwanted prior activation of the pyrotechnic material **108** of the device. This catch **112** is removed at the time of deployment.

The cartridge **92** is situated and held between an upper spring **114** and a lower spring **116**. The lower spring **116** allows the cartridge to be pushed down to a level whereby the firing pin **110** actuates the pyrotechnic material **108** at a predetermined pressure appropriate to that produced by a vehicle passing thereon.

Alternatively, the pyrotechnic material **108** can be actuated by a remote control.

When a vehicle to be arrested rides onto the tire attaching device **90**, the sharp hollow spike **94** penetrates the vehicle tire **31** and pressure on the cartridge **92** causes the firing pin **110** activate the pyrotechnic material **104.** The material **104** escapes through the top opening of the spike **94** and enters the tire **31** which causes the tire to be blasted off its wheel rim, thus arresting the vehicle.

To assemble a new tire attaching device **90**, a new cartridge may simply be screwed into the place of the expended cartridge.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown by the exemplary embodiments described hereinabove. Thus, the "stick-in-the-wheel" concept of Figs. 1 to 3 may be realized in the way shown in Figs. **12A-12D**.

Referring to Figs. **12A-12D**, a device **110** for arresting a land-vehicle having rubber tires may comprise sheet-like strips or stickers **112** designed to be arranged side by side on the road surface **37**. The stickers **112** may be more or less dimensioned corresponding to the tire size of the expected vehicle to be arrested, or alternatively may be narrower than the tires whereby a number of stickers **112** will engage the tires. The stickers **112** are typically elongated and oriented generally parallel to the road surface **37** or to the expected direction of the vehicle.

The stickers **112** have a top side **114** and a bottom side **116**. On the top side **114** there is a tire engaging member in the form of a sticky material **118** and/or a plurality of barbs (spikes) **14** which stick out therefrom. The sticky material or barbs **118, 14** are designed to engage with a rubber tire **31** of the

vehicle when the vehicle rolls over it. Thus, when the tires **31** (the leading, typically front tires) of the vehicle roll upon the stickers **112**, corresponding stickers wrap around those tires, as shown in Fig. **12D**, until a rod similar to the rod **16** of Fig. **1A** is engaged.

However, the wrapped stickers **112** may be effective even without an associated rod, if the bottom side **116** of the sticker **112** is made smooth and slippery, having a very low coefficient of friction. For example, the sticker may have a flexible steel net embedded or attached to its bottom side **116**. When the stickers **112** wrap around the tires **31**, the bottom side **116** thereby essentially becomes the road engaging surface of the corresponding tires **31**. Due to their low coefficient of friction, the bottom side **116** either spins on the road surface **37** such that the vehicle cannot progress or the slipperiness causes loss of control whereby the driver of the vehicle is forced to stop.